

ASTRONOMICAL SOCIETY OF LONDON.

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A PAPER was read, "On the errors likely to arise in the determination of the length of the pendulum, from a false position of the fixed axes." By Captain Everest, Member of the Society.

Pendulums having been lately constructed for the Honourable the East India Company, to be used in their presidencies of Bengal and Bombay, the Court of Directors expressed a desire that Captain Everest should explain their nature and use to the gentlemen cadets at Addiscombe: he was thus led to consider with minuteness the different errors which might be supposed likely to affect the accuracy of the experiment, in the full expectation that they would be found, as has always been supposed, wholly insignificant. The result of these investigations has, however, not corresponded with his expectations.

Captain Everest supposes the bar, of which the pendulum is composed, to be a rectangular prism, suspended at one extremity by a line, inflexible and void of weight, as its axis. This axis ought to be perpendicular both to the length and breadth of the bar, and is so placed by the artist to the best of his ability. It is, however, evident that the axis may deviate from this position in two ways:—1st, It may not be at right angles with the breadth of the bar; and 2dly, It may not be so with regard to the length.

In the first hypothesis Captain Everest ascertains the length of the isochronous simple pendulum, and finds that it is shorter than it would be if the axis of suspension were perpendicular to the breadth, by a quantity depending upon the dimensions of the rectangular bar, and the angle by which the axis may be conceived to be displaced or *twisted* from its proper position. Reducing his formula into numbers for the pendulums made by Mr. Jones, of Charing Cross, and also for Mr. Baily's pendulum, he finds that, if the twisting of the axis be supposed $= 1^{\circ} 45'$, the pendulum would, in either instance, be shortened 0.00001 inches very nearly; and that if the error be supposed $= 0^{\circ} 33'$, this quantity would not exceed 0.000001 inches; from which he concludes, that we may safely neglect any error likely to arise from this cause.

In the second hypothesis, that is, when the axis is not at right angles to the length of the pendulum, but deviates from this position by a given angle (x), Captain Everest finds the following diminution of the apparent length of the isochronous simple pendulum l :—

Values of δl in Inches.	Values of the deviation α .			
	Mr. JONES's Pendulum.		Mr. BAILY's Pendulum.	
0.1	4°	5'	4°	3'
0.01	1	18	1	16
0.001	0	24½	0	24
0.0001	0	7¾	0	7⅔
0.00001	0	2½	0	2½

Whence he concludes, that a much more serious error would be likely to arise from this source than from that first considered, and proceeds to shew that when a convertible bar pendulum is used for determining the length of the simple seconds pendulum, as in the experiments mentioned by Mr. Baily (*Phil. Mag.* Feb. 1829), there are concomitant causes which still further increase this error.

One of the axes in Mr. Baily's pendulum is placed as nearly as is practicable at the end of the bar, and the other axis at a distance from the former of about $\frac{2}{3}$ the whole length. These axes are made *convertible* by experiment; and if they be both perpendicular to the length of the bar, the distance between them will give the true length of the isochronous simple pendulum. Now, suppose the upper axis to be inclined,—the time of vibration will be diminished; and therefore, *to preserve the condition of convertibility*, we must suppose the reciprocal axis, which remains perpendicular, to be so shifted as to diminish the time of vibration by an equal quantity. It will easily be seen that this can only be done by removing it farther from the centre of gravity, and therefore from the upper axis; and thus, not only will the time of vibration be diminished, but the apparent length of the pendulum (being the distance measured between convertible axes) will be increased. If, then, the length of the simple pendulum vibrating seconds be deduced from a pair of knife-edges thus placed, it is clear that a value in excess will be obtained.

Again, suppose both axes inclined, and parallel to each other, the apparent or measured length of the pendulum will exceed the true length, which in this case is the *perpendicular* distance between the axes. Captain E., however, finds that this error is less than on the supposition made above. But if the extreme axis be now supposed perpendicular, the time of vibration about it will be increased, therefore the reciprocal axis (still supposed inclined at the original angle) must be so shifted as to increase the time of vibration, in order *to preserve the condition of convertibility*. This can only be effected by bringing it nearer to the centre of gravity, and thus shortening the apparent length of the pendulum. If the length of

the simple pendulum were determined from a pair of knife-edges thus placed, it appears that the value would be in defect; and Captain E. finds "that the apparent length exceeds the true length in the first hypothesis by three times as much as the true length exceeds the apparent length in the last hypothesis, the angle of deviation being in both cases the same."

He then proceeds to consider the discrepancies observed by Mr. Baily, upon the following suppositions, viz.—that the first extreme axis is inclined while its reciprocal is perpendicular to the bar, and that the second extreme axis is perpendicular while its reciprocal is inclined at the same angle as the first extreme axis; when he finds that an inclination of $0^{\circ} 49'$ would reduce both measures to the same length, and concludes as follows:—"However opinions may differ respecting my success in clearing up the discordancies alluded to by Mr. Baily, few are there, perhaps, but will regret that, previous to the introduction of the knife-edge into general practice, some mode of adjustment had not been devised, or some steps taken to inquire into the nature and effects of deviations, such as all instruments must be liable to. Doubtless, it would have been more masterly had the above investigation taken a wider range, and applied to the general case of any two deviations, x and y , and axes any how posited, provided they were synchronous. It is imperfect, too, in as far as the knife-edges themselves are not taken into consideration; but it is plain, that if, without these minutiae, no sensible effect is produced, none will arise from their influence alone. It will be time enough to furnish formulæ of correction when we have the means of detecting our errors. Let some ingenious person devise the method of affecting the angle which the line passing through the centre of gravity makes with the axis; and if no abler person offers to undertake the task, I will willingly resume my labours."

A paper was then read from James Prinsep, Esq., assay-master of the mint at Benares, containing the observation of a solar eclipse on the 13th and 14th of April, 1828, at Benares, with an account of the instrument, and the periods of the eclipse as obtained by construction. Mr. P. observed the transits of the limbs of the sun and of the cusps over the wire of an equatorial telescope.

"During the whole of the eclipse the atmosphere was unclouded, but, notwithstanding that barely the twentieth of the solar disc was at one time visible, the diminution of light was not such as to strike an inadvertent observer; the shadows of objects were fainter, but well defined, and the eye could not attempt to view the sun undefended; a thermometer placed in the sunshine on the equatorial fell from 110° to 95° in the interval between 4^{h} and $4^{\text{h}} 40^{\text{m}}$ P.M.; it rose again as high as 99° before sunset. Captain Herbert found at Almorab, by a photometer of his own contrivance, that the light was just equal to that of a cloudy day."

The next paper read consisted of Observations made at the Calton Hill Observatory, Edinburgh, (lat. $55^{\circ} 57' 20''$ N.; long. $12^{\text{m}} 44^{\text{s}}$ west of Greenwich):—1st, Of transits of the moon and

moon-culminating stars, in 1828, by Mr. Thomas Henderson; 2d, Of occultations of stars by the moon, by Mr. John Adie. The longitude of Edinburgh west of Greenwich, computed by Mr. Henderson, from eleven corresponding observations of the first limb and three of the second limb, is $12^m 40^s.55$.

A paper was also read, containing the places of Encke's comet, as reduced from thirty observations made by Mr. Dunlop, between October 26 and December 25, 1828, at Sir Thomas Brisbane's Observatory, Makerstoun, Roxburghshire.

There was, lastly, read a paper "On preserving the pivots of astronomical instruments;" by Lieutenant Peter Lecount, R.N. As the pivots of astronomical instruments are generally of steel, working in brass sockets, and are of necessity kept oiled, it would seem that when the oil becomes acid the galvanic arrangement is formed, and the steel pivot is decomposed and not the brass. Mr. L. therefore recommends that the pivots and sockets should be of the same metal, or, if this be inconvenient, that the pivots should be cleaned and fresh oil applied before acidity occurs, especially in the transit instrument.

Copy of the Regulations of the Council, relative to the Instruments of the Society, alluded to in the Annual Report, Feb. 13, 1829.

1. THAT a book be kept, to be called the Instrument Book, in which shall be inserted a full and particular description of every instrument that may belong to the Society, with an inventory of its several parts; together with the date when it was presented to the Society, and the name of the donor, as well as such other memoranda relative to the same as may be considered expedient.
2. That on every instrument belonging to the Society, and on their several parts, a sufficient mark, inscription, or number, be engraved, (and in the particular case of object-glasses, written with a diamond), for the purpose of identifying the same.
3. That when any instrument has been presented or left to the Society, such presentation or bequest shall be announced at the next ordinary meeting; and the instrument shall not be lent to any person till after one month from such announcement.
4. That when any person is desirous of borrowing an instrument of the Society, he shall state (in writing) to the Council such his desire, and the object he has in view: and no instrument shall be lent but on such written application.
5. That no instrument whatever shall at any time be lent for a longer period than three years; and that at the end of that term it shall be returned to the Society, unless the Council shall be of opinion that it would be expedient to extend the loan for another period, when they shall be at liberty so to do.
6. That all expense of moving and transporting an instrument from and to the Society be defrayed by the borrower, unless the Council shall otherwise direct at the time.
7. That the borrower of any instrument be requested to communicate to the Society, from time to time, the observations that he may make with the same.
8. That no borrower be allowed to make any alteration in an instrument, or any of its parts, without leave of the Council.
9. That no instrument shall be taken out of the country without special leave of the Council.
10. That every borrower shall sign a written engagement to return the instrument to the Society in as good a state as he received it (fair wear and tear excepted), in conformity with the 5th Regulation; and also to abide by these Regulations, as far as he is concerned.

